SOME RESEARCHES IN THE FAR EASTERN SEASONAL CORRELATIONS.

551.54 : 551.524 (520) (469.9)

(FOURTH NOTE.) [1]

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1. *Correlation between the April pressure-difference Ponta Delgada–Stykkisholm and the mean of the following August temperatures at Nemuro and Miyako.*—In the Third Note I traced a parallelism between the variation of the difference of the April barometric pressure at Ponta Delgada, Azores, and Stykkisholm, Iceland, and the mean of the following August temperatures at Nemuro and Miyako, in northern Japan. The present Note gives the materials discussed and the correlation coefficient computed. The Stykkisholm data are based on Dr. Lockyer's pressure table (see this REVIEW, June, 1917, p. 299, footnote 3), supplemented by material extracted from the Meteorologisk Aarbog of the Danish Meteorological Institute. Table 1, below, gives the pressure and temperature data for the four stations under discussion, x standing for the variation of the difference of the April pressure Azores–Iceland and q for the variation of the August mean temperature Nemuro + Miyako.

TABLE 1.—*April pressure-difference Ponta Delgada–Stykkisholm correlated with the mean August temperature at Nemuro and Miyako.*

Years.	Pressure.				Temperature.					
	Ponta Delgada.	Stykkisholm.	Difference	δ (p-s) or x.	Nemuro.	Miyako.	Mean variation of n and m.	x. q	x²	q²
	p	s	(p−s).	x	n	m	q			
	mm.	mm.	mm.		°C.	°C.				
1883	764.9	750.6	14.3	......	19.9	20.9	......			
1884	59.8	56.5	3.3	−11.0	16.4	20.0	−2.2	+24.20	121.00	4.84
1885	66.7	53.7	13.0	+ 9.7	16.9	22.6	+1.6	+15.52	94.09	2.56
1886	761.5	755.8	5.7	− 7.3	19.8	24.8	+2.6	−18.98	53.29	6.76
1887	59.1	60.6	−1.5	− 7.2	18.8	22.2	−1.8	+12.97	51.84	3.24
1888	66.2	61.0	5.2	+ 6.7	17.4	22.9	−0.4	− 2.68	44.89	0.16
1889	68.9	54.6	14.3	+ 9.1	18.2	22.1	0.0	0.00	82.81	0.00
1890	67.5	52.5	15.0	+ 0.7	19.3	22.5	+0.8	+ 0.56	0.49	0.64
1891	762.4	758.9	3.5	−11.5	17.1	21.0	−1.9	+21.85	132.25	3.61
1892	61.1	57.2	6.9	+ 3.4	17.3	23.0	+1.1	+ 3.74	11.56	1.21
1893	62.7	54.8	7.9	+ 1.0	17.3	22.6	−0.2	− 0.20	1.00	0.04
1894	66.6	52.6	14.0	+ 6.1	17.8	23.2	+0.6	+ 3.66	37.21	0.36
1895	62.0	56.0	6.0	− 8.0	15.8	21.6	−1.8	+14.40	64.00	3.24
1896	768.7	752.6	16.1	+10.1	17.7	23.0	+1.7	+17.17	102.01	2.89
1897	67.4	46.5	20.9	+ 4.8	17.0	21.5	−1.1	− 5.28	23.04	1.21
1898	65.1	48.7	16.4	− 4.5	16.4	22.8	+0.4	− 1.90	20.25	0.16
1899	65.4	59.1	6.3	−10.1	15.4	22.0	−0.9	+ 9.09	102.01	0.81
1900	65.3	54.6	10.7	+ 4.4	18.2	23.5	+2.2	+ 9.68	19.36	4.84
1901	764.8	752.0	12.8	+ 2.1	17.9	22.8	−0.5	− 1.05	4.41	0.25
1902	61.1	59.3	1.8	−11.0	14.5	18.4	−3.9	+42.90	121.00	15.21
1903	64.7	57.4	7.3	+ 5.5	15.9	20.6	+1.8	+ 9.90	30.25	3.24
1904	69.6	47.7	21.9	+14.6	18.5	22.2	+2.1	+30.66	213.16	4.41
1905	63.7	62.5	1.2	−20.7	14.7	18.2	−3.9	+80.73	428.49	15.21
1906	768.4	752.1	16.3	+15.1	15.7	19.6	+1.2	+18.12	228.01	1.44
1907	66.2	52.9	13.3	− 3.0	17.5	21.2	+3.2	− 9.60	9.00	10.24
1908	65.1	62.5	2.6	−10.7	17.8	22.6	−0.2	+ 2.14	111.49	0.04
1909	64.1	54.6	9.5	+ 6.9	16.8	21.6	−1.5	−10.35	47.61	2.25
1910	63.1	59.0	4.1	− 5.4	16.3	20.5	−0.8	+ 1.64	29.16	0.64
1911	763.8	758.8	5.0	+ 0.9	15.9	22.1	+0.6	+ 0.54	0.81	0.36
1912	67.7	57.3	10.4	+ 5.4	15.6	21.6	−0.4	− 2.17	29.16	0.16
Sums								+270.26	2,213.65	90.02

[1] For the previous Notes see this REVIEW, January, 1916, 44 : 17; May, 1917, 45 : 238, June, 1917, 45 : 299.

In order to eliminate the secular variation which is superposed on the variation under consideration, I have computed the coefficient of correlation for the variations of the pressure and temperature instead of for their deviations from the mean values. Let r_{qx} be the correlation-coefficient for the April pressure-difference Ponta Delgada–Stykkisholm and the August temperature Nemuro + Miyako, and let E_{qx} be the probable error; then we have

$$r_{qx} = + \frac{270.26}{(2213.65)\ \ (90.02)^{\frac{1}{2}}} = + 0.61$$

$$E_{qx} = \pm\ 0.6745 \frac{1 - (0.61)^2}{(29)^{\frac{1}{2}}} = \pm\ 0.079$$

From the above we see that the parallelism between both elements is very striking during these 29 years, from 1884 to 1912.

2. *Correlation between the March pressure-difference Zikawei–Miyazaki and the mean of the following August temperatures at Nemuro and Miyako.*—In my First Note I traced a remarkable parallelism between the barometric gradient at Zikawei (near Shanghai) for March and the mean temperature in northern Japan for the following summer. In the present note will be given the result of my computation of the correlation-coefficient between the variation of the pressure-difference Zikawei–Miyazaki for March and the mean of the following August temperatures at Nemuro and Miyako. The Zikawei Observatory data from 1883 to 1910 have been extracted from the Bulletin des Observations of that observatory, and those for 1911 and 1912 I owe to the kindness of Father L. Froc, director of the same. The temperature data for the Japanese stations have been taken from the annual reports of the Central Meteorological Observatory, Tokyo. The actual values of the quantities discussed are graphically presented in figure 1.

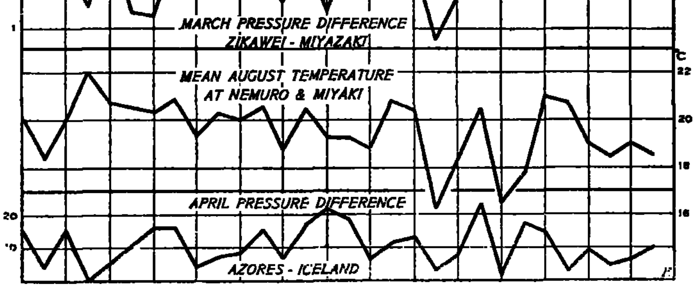

FIG. 1.—Graphic comparison of the elements correlated in this Fourth Note.

TABLE 2.—*Correlation of the March pressure-difference Zikawei—Miyazaki with the mean of the following August temperatures Nemuro + Miyako (q=mean variation of latter).*

Years.	Pressure. Zikawei.	Miyazaki.	(Zik.—Mi.)	δ(Zik.—Mi.)=y.	y^2	$q.y$	$x.y$
	mm.	*mm.*	*mm.*				
1883	765.5	762.5	3.0				
1884	64.7	62.1	2.6	−0.4	0.16	+ 0.88	+ 4.40
1885	66.6	64.0	2.6	0.0	0.00	0.00	0.00
1886	765.6	764.1	1.5	−1.1	1.21	− 2.86	+ 8.03
1887	66.3	63.3	3.0	+1.5	2.25	− 2.70	−10.80
1888	65.0	63.6	1.4	−1.6	2.56	+ 0.64	−10.72
1889	65.7	64.4	1.3	−0.1	0.01	0.00	− 0.91
1890	66.2	63.4	2.8	+1.5	2.25	+ 1.20	+ 1.05
1891	765.9	763.6	2.3	−0.5	0.25	+ 0.95	+ 5.75
1892	66.7	63.4	3.3	+1.0	1.00	+ 1.10	+ 3.40
1893	65.4	63.5	1.9	−1.4	1.96	+ 0.28	− 1.40
1894	65.7	63.4	2.3	+0.4	0.16	+ 0.24	+ 2.44
1895	65.1	63.5	1.6	−0.7	0.49	+ 1.26	+ 5.60
1896	767.3	764.7	2.6	+1.0	1.00	+ 1.70	+10.10
1897	65.7	64.4	1.3	−1.3	1.69	+ 1.43	− 6.24
1898	66.0	63.3	2.7	+1.4	1.96	+ 0.56	− 6.30
1899	66.0	63.3	2.7	0.0	0.00	0.00	0.00
1900	65.9	63.4	2.5	−0.2	0.04	− 0.44	− 0.88
1901	767.6	765.1	2.5	0.0	0.00	0.00	0.00
1902	63.7	63.0	0.7	−1.8	3.24	+ 7.02	+19.80
1903	63.9	62.2	1.7	+1.0	1.00	+ 1.80	+ 5.50
1904	65.2	62.6	2.6	+0.9	0.81	+ 1.89	+13.14
1905	66.7	64.2	2.5	−0.1	0.01	+ 0.39	+ 2.07
1906	766.5	763.4	3.1	+0.6	0.36	+ 0.72	+ 9.06
1907	66.0	63.1	2.9	−0.2	0.04	− 0.64	+ 0.60
1908	67.0	64.1	2.9	0.0	0.00	0.00	0.00
1909	66.7	64.1	2.6	−0.3	0.09	+ 0.45	− 2.07
1910	65.3	63.5	1.8	−0.8	0.64	+ 0.72	+ 4.32
1911	764.5	762.7	1.8	0.0	0.00	0.00	0.00
1912	65.7	62.8	2.9	+1.1	1.21	− 0.44	+ 5.94
Sums					24.39	+16.15	+61.88

From the data given in Table 2 I have computed the correlation coefficients and have obtained the following:

$$r_{qy} = + \frac{16.15}{(24.39)^{\frac{1}{2}}\ (90.02)^{\frac{1}{2}}} = +0.31; \qquad E_{qy} = \pm 0.113.$$

$$r_{xy} = + \frac{61.88}{(2213.65)^{\frac{1}{2}}\ (24.39)^{\frac{1}{2}}} = +0.27; \qquad E_{xy} = \pm 0.116.$$

3. *Regression equation.*—Having computed the correlation coefficients and the probable errors we proceed to calculate the constants of the regression equation connecting the three quantities under consideration.

Calling q the mean variation of the August temperature for Nemuro + Miyako,

x the April pressure-difference Ponta Delgada – Stykkisholm,

y the March pressure-difference Zikawei – Miyazaki,

σ_x the standard deviation of x, etc., we have

	q	x	y
q	+1.00	+0.61	+0.31
x	+0.61	+1.00	+0.27
y	+0.31	+0.27	+1.00

$$r_{qx} = +0.61, \quad \sigma_x = \sqrt{22.1365} = 47.0$$

$$r_{qy} = +0.31, \quad \sigma_y = \sqrt{24.39} = 4.9$$

$$r_{xy} = +0.27, \quad \sigma_q = \sqrt{90.02} = 9.5$$

Let us assume that

$$q = ax + by,$$

and try to calculate a and b by the method of least squares using the above data. The normal equations are

$$\Sigma qx = a\Sigma x^2 + b\Sigma xy,$$
$$\Sigma qy = a\Sigma xy + b\Sigma y^2,$$

or

$$\frac{\Sigma qx}{\Sigma x^2} = a + b\frac{\Sigma yx}{\Sigma x^2}, \quad \frac{\Sigma qy}{\Sigma y^2} = a\frac{\Sigma xy}{\Sigma y^2} + b.$$

Since

$$r_{qx} = \frac{\Sigma qx}{\sqrt{\Sigma x^2}\sqrt{\Sigma q^2}}, \text{ and } r_{qy} = \frac{\Sigma qy}{\sqrt{\Sigma y^2}\sqrt{\Sigma q^2}},$$

we have

$$r_{qx}\frac{\sigma_q}{\sigma_x} = a + br_{yx}\frac{\sigma_y}{\sigma_x}, \quad r_{qy}\frac{\sigma_q}{\sigma_y} = ar_{xy}\frac{\sigma_x}{\sigma_y} + b.$$

Solving these equations we get

$$a = \frac{(r_{qx} - r_{qy}r_{xy})\frac{\sigma_q}{\sigma_x}}{1 - (r_{xy})^2},$$

$$b = \frac{(r_{qy} - r_{qx}r_{xy})\frac{\sigma_q}{\sigma_y}}{1 - (r_{xy})^2}.$$

Inserting the values of r_{qx}, r_{qy}, etc., into the above equations we have

$$a = \frac{(0.61 - 0.31 \times 0.27) \times 9.5/47}{1 - (0.27)^2} = 0.115$$

$$b = \frac{(0.31 - 0.61 \times 0.27) \times 9.5/4.9}{1 - (0.27)^2} = 0.648,$$

therefore

$$q = 0.115x + 0.648y, \tag{1}$$

or the variation of the mean August temperature for Nemuro + Miyako equals 0.115 times the variation of the April pressure-difference Ponta Delgada–Stykkisholm plus 0.648 times the variation of the March pressure-difference Zikawei-Miyazaki.

Table 3 contains the departures of the calculated values from the actually observed ones.

TABLE 3.—*Comparison of the calculated with the observed values of* q *(variation of the mean August temperature for Nemuro–Miyako).*

$$q = 0.115x + 0.648y.$$

Years.	x	y	Temperature variation, q Calculated	Observed.	Difference Cal.—Obs.
			°C.	°C.	°C.
1884	−11.0	−0.4	−1.5	−2.2	+0.7
1885	+ 9.7	0.0	+1.1	+1.6	−0.5
1886	− 7.3	−1.1	−1.6	+2.6	*−4.2
1887	− 7.2	+1.5	−1.8	−1.8	0.0
1888	+ 6.7	−1.6	−0.3	−0.4	+0.1
1889	+ 9.1	−0.1	+1.0	0.0	+1.0
1890	+ 0.7	+1.5	+1.1	+0.8	+0.3
1891	−11.5	−0.5	−1.4	−1.9	+0.5
1892	+ 3.4	+1.0	+1.0	+1.1	−0.1
1893	+ 1.0	−1.4	−0.8	−0.2	−0.6
1894	+ 6.1	+0.4	+1.0	+0.6	+0.4
1895	− 8.0	−0.7	−1.0	−1.8	+0.8
1896	+10.1	+1.0	+1.8	+1.7	+0.1
1897	+ 4.8	−1.3	−0.3	−1.1	+0.8
1898	− 4.5	+1.4	+0.4	+0.4	0.0
1899	−10.1	0.0	−1.2	−0.9	−0.3
1900	+ 4.4	−0.2	+0.4	+2.2	−1.8
1901	+ 2.1	0.0	+0.2	−0.5	*+0.7
1902	−11.0	−1.8	−2.4	−3.9	+1.5
1903	+ 5.5	+1.0	+1.3	+1.8	−0.5
1904	+14.6	+0.9	+2.3	+2.1	+0.2
1905	−20.7	−0.1	−2.4	−3.9	+1.5
1906	+15.1	+0.6	+2.1	+1.2	+0.9
1907	− 3.0	−0.2	−0.5	+3.2	*−3.7
1908	−10.7	0.0	−1.2	−0.2	−1.0
1909	+ 6.9	−0.3	+0.6	−1.5	*+2.1
1910	− 5.4	−0.8	−1.1	−0.8	−0.3
1911	+ 0.9	0.0	+0.1	+0.6	−0.5
1912	+ 5.4	+1.1	+1.3	−0.4	*+1.7

* Variations of opposite sign.

A glance at the table shows us that the calculated and observed variations of the August temperature for Nemuro + Miyako are in good agreement, barring a few exceptions, or that at least their signs are in harmony. Hence it may be of practical value for the purpose of issuing the seasonal forecast.

4. *Correlation between the pressure-variation at Sydney for January and the temperature-variation at Nemuro + Miyako for the following August.*—It has been found that the variations of the barometric pressure at Sydney, Australia, for January are in harmony with those of the air temperature at Nemuro-Miyako for the following August. The pressure data for Sydney for 1883 to 1907 have been taken from Dr. Lockyer's tables (loc. cit.). Table 4 gives these pressure data for Sydney and the temperature data for the Japanese stations.

TABLE 4.—*Correlation between January pressure variation at Sydney, z, and the variation in the following August temperature at Nemuro Miyako,* q.

Years.	Sydney pressures. Obs.	Variation, z	q	zq	z^2	q^2
	mm.	*mm.*	°*C.*		*mm.*	°*C.*
1883	757.1					
1884	54.3	−2.8	−2.2	6.16	7.84	4.84
1885	57.1	+2.8	+1.6	4.48	7.84	2.56
1886	757.9	+0.8	+2.6	2.08	0.64	6.76
1887	55.6	−2.3	−1.8	4.14	5.29	3.24
1888	56.1	+0.5	−0.4	−0.20	0.25	0.16
1889	57.0	+0.9	0.0	0.00	0.81	0.00
1890	58.7	+1.7	+0.8	1.36	2.89	0.64
1891	756.1	−2.6	−1.9	4.94	6.76	3.61
1892	56.6	+0.5	+1.1	0.55	0.25	1.21
1893	54.1	−2.5	−0.2	0.50	6.25	0.04
1894	55.9	+1.8	+0.6	1.08	3.24	0.36
1895	56.9	+1.0	−1.8	−1.80	1.00	3.24
1896	756.2	−0.7	+1.7	−1.19	0.49	2.89
1897	55.1	−1.1	−1.1	1.21	1.21	1.21
1898	56.8	+1.7	+0.4	0.68	2.89	0.16
1899	51.9	−4.9	−0.9	4.41	24.01	0.81
1900	57.8	+5.9	+2.2	12.98	34.81	4.84
1901	755.1	−2.7	−0.5	1.35	7.29	0.25
1902	54.3	−0.8	−3.9	3.12	0.64	15.21
1903	57.8	+3.5	+1.8	5.60	12.25	3.24
1904	57.0	−0.8	+2.1	−1.69	0.64	4.41
1905	56.8	−0.2	−3.9	1.28	0.04	15.21
1906	757.3	+0.5	+1.2	0.60	0.25	1.44
1907	55.4	−1.9	+3.2	−6.08	3.61	10.24
Sums				45.56	131.19	86.57

From the data in Table 4 I have deduced the correlation-coefficient and the probable error,

$$r_{qz} = +\frac{(45.56)}{(131.19)^{½}\ (86.57)^{½}} = +0.49; \quad E_{qz} = \pm 0.106.$$

5. Again, I have computed the correlation-coefficients of any two of the four quantities q, x, y, and z, using the data for the 24 years from 1884 to 1907, inclusive. The following are the results of my computations:

$$r_{qx} = \frac{\Sigma qx}{\sqrt{\Sigma x^2}\sqrt{\Sigma q^2}} = +\frac{275.46}{\sqrt{1995.42}\sqrt{86.57}} = +0.67, \quad E_{qx} = \pm 0.076;$$

$$r_{qy} = \frac{\Sigma qy}{\sqrt{\Sigma q^2}\sqrt{\Sigma y^2}} = +\frac{15.42}{\sqrt{86.57}\sqrt{22.45}} = +0.35, \quad E_{qy} = \pm 0.121;$$

$$r_{qz} = \frac{\Sigma qz}{\sqrt{\Sigma q^2}\sqrt{\Sigma z^2}} = +\frac{44.56}{\sqrt{86.57}\sqrt{131.19}} = +0.43, \quad E_{qz} = \pm 0.106;$$

$$r_{xz} = \frac{\Sigma zx}{\sqrt{\Sigma z^2}\sqrt{\Sigma x^2}} = +\frac{197.83}{\sqrt{131.19}\sqrt{1995.42}} = +0.39, \quad E_{xz} = \pm 0.117;$$

$$r_{xy} = \frac{\Sigma xy}{\sqrt{\Sigma x^2}\sqrt{\Sigma y^2}} = +\frac{53.69}{\sqrt{1995.42}\sqrt{22.45}} = +0.25, \quad E_{xy} = \pm 0.129;$$

$$r_{yz} = \frac{\Sigma yz}{\sqrt{\Sigma y^2}\sqrt{\Sigma z^2}} = +\frac{10.62}{\sqrt{22.45}\sqrt{131.19}} = +0.20, \quad E_{yz} = \pm 0.132;$$

$$\sigma_x = \sqrt{1995.4} = 44.67 \quad \sigma_y = \sqrt{22.45} = 4.74$$

$$\sigma_z = \sqrt{131.19} = 11.45 \quad \sigma_q = \sqrt{86.57} = 9.30$$

6. *Regression equation resumed.*—In Paragraph 4 I have obtained a regression equation

$$q = 0.115x + 0.648y,$$

for the case of two variables x and y. In the present case in which the third variable z is available we shall assume that

$$q = ax + by + cz.$$

Then, in applying the method of least squares we obtain the following normal equations:

$$\Sigma qx = a\Sigma x^2 + b\Sigma xy + c\Sigma zx,$$

$$\Sigma qy = a\Sigma xy + b\Sigma y^2 + c\Sigma zy,$$

$$\Sigma qz = a\Sigma xz + b\Sigma yz + c\Sigma z^2.$$

Expressing in terms of the correlation-coefficients and the standard deviations we have

$$r_{qx}\frac{\sigma_q}{\sigma_x} = a + br_{xy}\frac{\sigma_y}{\sigma_x} + cr_{xz}\frac{\sigma_z}{\sigma_x},$$

$$r_{qy}\frac{\sigma_q}{\sigma_y} = ar_{xy}\frac{\sigma_x}{\sigma_y} + b + cr_{yz}\frac{\sigma_z}{\sigma_y},$$

$$r_{qz}\frac{\sigma_q}{\sigma_z} = ar_{xz}\frac{\sigma_x}{\sigma_z} + br_{yz}\frac{\sigma_y}{\sigma_z} + c.$$

In the present problem these constants are

	q	x	y	z
q	+1.00	+0.67	+0.35	+0.43
x	+0.67	+1.00	+0.25	+0.39
y	+0.35	+0.25	+1.00	+0.20
z	+0.43	+0.39	+0.20	+1.00

and

$$\sigma_x = \sqrt{1995.4} = 44.67, \quad \sigma_y = \sqrt{22.45} = 4.74,$$
$$\sigma_z = \sqrt{131.19} = 11.45, \quad \sigma_q = \sqrt{86.57} = 9.30.$$

Putting these values into the normal equations we have

$$0.1395 = a + 0.0265b + 0.1000c,$$
$$0.6867 = 2.3560a + b + 0.4831c,$$
$$0.3492 = 1.5211a + 0.0828b + c,$$

Solving for a, b, and c, we get

$$a = 0.117, \quad b = 0.284, \quad c = 0.149,$$

Hence the regression equation becomes

$$q = 0.117x + 0.284y + 0.149z, \tag{2}$$

or the variation of the mean August temperature for Nemuro-Miyako equals 0.117 times the variation of the April pressure difference Ponta Delgada—Stykkisholm plus 0.284 times the variation of the March pressure-difference Zikawei—Miyazaki plus 0.149 times the variation of the January pressure Sidney, N. S. W.

Table 5 presents the departures of the calculated values of the variations of the August temperature for Nemuro-Miyako from the actual values.

TABLE 5. *Differences between the calculated and actually observed values of* q (*variation of the mean August temperature for Nemuro-Miyako*), *as computed by the formula*

$$q=0.117x+0.284y+0.149z.$$

Years.	x	y	z	Variation of mean August temperature Nemuro + Miyako. q		
				Calculated.	Observed.	Calculated − Observed.
	mm.	*mm.*	*mm.*	°*C.*	°*C.*	°*C.*
1884	−11.0	−0.4	−2.8	−1.8	−2.2	+0.4
1885	+ 9.7	0.0	+2.8	+1.5	+1.6	−0.1
1886	− 7.3	−1.1	+0.8	−1.1	+2.6	−3.7
1887	− 7.2	+1.5	−2.3	−0.7	−1.8	+1.1
1888	+ 6.7	−1.6	+0.5	+0.4	−0.4	+0.8
1889	+ 9.1	−0.1	+0.9	+1.2	0.0	+1.2
1890	+ 0.7	+1.5	+1.7	+0.8	+0.8	0.0
1891	−11.5	−0.5	−2.6	−1.8	−1.9	+0.1
1892	+ 3.4	+1.0	+0.5	+0.8	+1.1	−0.3
1893	+ 1.0	−1.4	−2.5	+0.1	−0.2	−0.3
1894	+ 6.1	+0.4	+1.8	+1.1	+0.6	+0.5
1895	− 8.0	−0.7	+1.0	−0.9	−1.8	+0.9
1896	−10.1	+1.0	−0.7	+1.1	+1.7	−0.6
1897	+ 4.8	−1.3	−1.1	−0.0	−1.1	+1.1
1898	− 4.5	+1.4	+1.7	+0.2	+0.4	+0.2
1899	−10.1	0.0	−4.9	−1.9	−0.9	−1.0
1900	+ 4.4	−0.2	+5.9	+1.3	+2.2	−0.9
1901	+ 2.1	0.0	−2.7	−0.2	−0.5	+0.3
1902	−11.0	−1.8	−0.8	−1.9	−3.9	+2.0
1903	+ 5.5	+1.0	+3.5	+1.4	+1.8	−0.4
1904	+14.6	+0.9	−0.8	+1.9	+2.1	−0.2
1905	−20.7	−0.1	−0.2	−2.4	−3.9	+1.5
1906	+15.1	+0.6	+0.5	+2.1	+1.2	+0.9
1907	− 3.0	−0.2	−1.9	−0.8	+3.2	*−4.0

* Calculated and observed values are of opposite sign.

6. *On the possibility of forecasting the August temperature for northern Japan.*—In northern Japan the August temperature is the dominant factor [2] for the rice crop of the year. When the air temperature in August is higher than the average Japan may expect a good harvest. On the contrary when the August temperature is lower than the normal we are to anticipate a very bad harvest. In recent times 1902, 1905, and 1913 had abnormally cool Augusts. In consequence there was failure of the rice crop, which resulted in a terrible famine in most of northern Japan. Attention of scientists has been called to the cause of this abnormal low temperature. Forecasting the approximate temperature for August many months in advance is the problem that confronts [the Japanese]. Some of them have found a close relation existing between the hydrographical and meteorological phenomena off our east coast, and have proposed to take systematic observations of sea temperature for the prediction of the general character of the summer. But it is not easy to make systematic observations of sea temperature. Moreover there is at present no special organization or institute for making systematic hydrographical observations on our [Japan's] coast. I have therefore intended, in default of better, to make a tentative application of statistical methods for the solution of the problem. My method of seasonal forecasting is based on the facts that the temperature variation in northern Japan for August is in harmony with that of the April pressure difference, Azores—Iceland, and that of the March pressure difference, Zikawei—Miyazaki. But, as in all efforts at the solution of seasonal forecasting, there are some tantalizing exceptions in this harmony of the pressure and temperature variations. Hence we can not hope to establish a definite law of prediction or to calculate the approximate August temperature many months in advance.

But the regression equation $q=0.115x+0.648y$, imperfect as it is, will serve to show at least the sense of variation of the air temperature of the coming August at the beginning of May when we have the telegraphic reports of the mean pressures at Ponta Delgada and Stykkisholm for April and those at Zikawei and Miyazaki for March. When the Sydney, N. S. W., pressure for January is available the regression equation

$$q=0.117x+0.284y+0.149z$$

is to be used.

It must be remarked here that the number of years for which data are available is inadequate for a correct knowledge of the relationships involved and the factors available are scanty. Hence future information and the introduction of new factors [3] are likely to modify the relative importance of the terms involved in the above equations to an appreciable extent.

551.590.2 : 551.578.1

SUN SPOTS, MAGNETIC STORMS, AND RAINFALL.[1]

By HENRYK ARCTOWSKI, Ph.D.

[Dated: Hastings-on-Hudson, N. Y., Sept. 13, 1917.]

Utilizing the results of Wolf's daily sunspot observations, Loomis noticed the fact that on the days of magnetic storms the sunspot relative numbers are much above the average and that secondary maxima occur 4 days before and 3 days after those of magnetic disturbances.

Recently this fact has been partially verified by Lord Kelvin.

On the other hand it is well known that Terby, then later Marchand, and finally Maunder, have admitted that magnetic storms frequently coincide with the passage of a sunspot through the central meridian—that Veeder, on the contrary, advocated a predominant influence of the appearance of sunspots on the eastern limb and that Riccò noticed the fact that very frequently magnetic disturbances occur about 45 hours after the passage of a sunspot through the meridian.

Without further statistical verification Arrhenius deduced from Riccò's observations that the magnetic storms are due to particles, carrying negative electricity, conveyed from the sun by the pressure of radiation.

Since the correlation noticed by Loomis really exists, at least as far as the principal maximum is concerned, it seemed interesting to me to verify which of the three hypotheses concerning the position occupied by the sunspots producing auroras and magnetic storms is correct.

It is easy to understand the importance of the question.

[2] A detailed discussion on the relation between the rice crop and the temperature, together with the correlation with the pressure variations, Azores-Iceland, Zikawei-Miyazaki, etc., will be given in a further note.

[3] The variation of the pressure at Cordoba, Argentine Republic, for April is in harmony with that of the August temperature in northern Japan.—*Author.*

[1] Author's abstract of "Note sur une corrélation entre orages magnétiques et la pluie;" "Positions héliographique des taches solaires et orages magnétiques." Par *Henryk Arctowski.* Mem.. Soc. degli spettrosc. ital., 1917. 6 (ii): 33–36.